TRANSACTION COSTS OF ENERGY EFFICIENCY IMPROVEMENT

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1. SYNOPSIS

This paper evaluates the importance of transaction costs in explaining the investment behaviour of firms in energy efficiency improvement.

2. ABSTRACT

Various technical studies describe a large potential of energy efficiency improvement measures which can be implemented at low costs. However, it is often argued that these costs do not reflect the full costs of the measures as they do not include transaction costs. Transaction costs are the costs of collecting information on, making decisions about, and monitoring the performance of investments. In this paper the character and magnitude of transaction costs in the implementation of energy efficiency improvements are investigated. The research is based on a literature survey and twelve interviews with energy managers of large firms in the Netherlands.

It was found that in the selected companies, the transaction costs mainly consist of information costs (2-6% of the investment), whereas the costs of decision making (1-2%) and monitoring (<1%) are much smaller. The firms gathered part of the information, on e.g. equipment and supplier options, after the investment decision. For the companies considered in this study, transaction costs of energy efficiency improvement measures are estimated to be between 3 and 8% of the investment.

3. INTRODUCTION

In recent years many studies have been performed that evaluate the costs of energy efficiency improvement measures through a so-called bottom-up analysis. In this type of analysis individual options for energy efficiency improvement are identified; subsequently for each measure potential energy savings and associated costs are determined on the basis of literature, information of suppliers of equipment etc. Examples of such studies are: de Beer et al (1994) and Koomey et al (1991). For an overview, see Grubb, (1993) or Lovins and Lovins (1991).

There has been a strong debate on the value of such studies (Levine et al. 1994; Wilson and Swisher, 1993; Sanstad and Howart, 1994). One of the comments is that not all the costs of energy conservation measures are included in such studies. A cost category that is mentioned as being neglected is transaction costs (Levine et al. 1994; Velthuijsen 1992). The aim of this paper is to get an estimate of the magnitude of these transaction costs. This is done in two ways. First of all, an overview is given of the use of the concept of transaction costs in literature and the applicability for cost evaluation of options for energy efficiency improvement. Subsequently, a first estimate is made of the actual transaction costs by carrying out a limited survey among twelve energy coordinators in industry.

Section 4 provides the results of the literature search on the concept of transaction costs. In section 5, the methods used in this study are described. The results of the survey are discussed in section 6. Section 7 provides a discussion and offers comments on the applicability of transaction costs in the field of energy analysis.

4. THE CONCEPT OF TRANSACTION COSTS

Transaction costs are mainly a theoretical concept. A large number of studies dealing with the theory of transaction costs has been performed (e.g. Williamson, 1989; Eggertson, 1990), but despite an intensive literature survey, few examples have been found in which transaction costs are actually calculated. In this chapter, after briefly describing some theory, we try to formulate a workable definition for transaction costs in the field of energy analysis. In the discussion, some of the examples in which transaction costs are estimated will be compared with those in this study.

Transaction costs were introduced as a relaxation of the neoclassical assumptions of full information and costless exchange, see e.g. Eggertson (1990). Transaction costs are, in general terms, costs that arise when individuals exchange ownership rights of economic assets (a theoretical review can be found in Williamson, 1989). The most common transaction is the purchase of a good or service. Because the buyer is not in a position to have full information on products and suppliers, he experiences costs in such a transaction. These transaction costs occur when getting information on the performance of the good and the reliability of the supplier ex ante, and in effecting the delivery and monitoring the performance of the good ex post (Eggertson 1990).

A useful definition of transaction costs is supplied by Matthews (in Eggertsson 1990): The fundamental idea of transaction costs is that they consist of the cost of arranging a contract ex ante and monitoring and enforcing it ex post, as opposed to production costs, which are the costs of executing a contract.

Regarding equipment transactions, Sanstad and Howarth (1994) suggest the following definition: Transaction costs are the costs of gathering, assessing and applying information on the characteristics and performance of equipment.

In this study, the transaction costs of energy efficiency improvement will include the costs of collecting information, decision making and monitoring the performance of the equipment.

5. METHODS

For the survey, it was decided to focus on large, energy intensive firms. They are responsible for an important share of the industrial energy use. The 50 largest energy consuming plants together represent about 65% of the Dutch industrial primary energy demand (Blok and Worrell 1992). The companies were selected at random within the branches of the heavy industry (metal industries, chemical industry, paper mills, building materials industry) and included four energy intensive firms in other sectors (food & beverages and textile). The firms were large in terms of turnover (>50 m. Dfl) and energy use (>150 TJ/y). 20 companies were approached, 12 of them cooperated with this study. For reasons of confidentiality, the names of the firms are not presented.

To gain insight into the process of implementation of energy efficiency improvement, interviews have been held with energy managers or managers of technical departments of firms. The selected companies all had an energy department, or a technical department with an energy coordinator. In exploratory interviews, information was gathered on investments in energy conservation. Although this was not explicitly asked for, most of the measures discussed were retrofit measures. Generally, four phases can be distinguished in the purchase of equipment (Fama and Jensen 1983):

(1) collecting of information
(2) decision making
(3) implementation
(4) monitoring

In the interviews, information was gathered on these four aspects for a number of recent investments in energy efficiency improvement. Registered were: the actors involved, a general outline of the activities carried out, and if possible an estimation of the costs involved.
To determine these costs, the amount of time employees spent in the four phases mentioned above was estimated. An approximation of the costs was made by multiplying the average hourly wage rates of the people concerned, with the amount of time these people spent on the implementation of a measure. The estimates were made by the interviewees.

In the research, only the transaction costs for the buyers of energy efficiency equipment are investigated. The sellers of energy equipment also experience transaction costs, but
this should be included in the price of the equipment and hence need not be estimated seperately. Therefore, transaction costs of sellers are not included in this research.

6. IMPLEMENTATION OF ENERGY EFFICIENCY IMPROVEMENTS

The implementation of energy efficiency improvements will be described, following the investment model of Jensen and Fama (1983), the structure of which was confirmed by the interviews. Also, the costs of the interviewed companies in the four phases are described. According to our definition of transaction costs, the costs made in phases (1) collection of information, (2) decision making and (4) monitoring are transaction costs. These transaction costs are estimated. The costs made in phase (3) implementation are not part of the transaction costs, and they are not estimated.

6.1 collecting of information

The large, energy-intensive companies surveyed generally have an energy department which deals with information on energy efficiency improvement technologies. If not, an energy coordinator is present in the technical department. Energy or technical departments report energy conservation possibilities to the plant management. The report includes a preliminary financial analysis, a brief technical description, and very brief comments on the possible impacts on production and pollution. When discussing the impact on production, the consequences for product quality, risks of production failures, and consequences for maintenance are addressed.
External information on energy efficiency improvement is provided by producers or suppliers of equipment, supplied by government agencies, found in branch periodicals, and exchanged with associates.

Two of the interviewed companies had already calculated the information costs themselves. These costs consisted of time spent on collecting and applying information. The information costs varied from project to project. For one firm, the information costs for a cogeneration installation (built in cooperation with the utility) were only 1% (on an investment of 13 m. ECU), whereas the information costs for an energy monitoring system were 6% (on an investment of 1 m. ECU). Two other investments which consisted of modifications of the production process to optimize the energy use had information costs of 2 and 2.5% for investments of 2 m. ECU and 3 m. ECU respectively. These figures may suggest that the information costs, as a fraction of the investments, tend to decrease as the size of the investment increases. The average information costs for these 4 investments were 3.3% for this firm. We have not enough data to settle this relation more precisely. A second firm calculated the average information costs for all energy investments in 1990. The information costs satisfying the same definition were on average 3-4%. In 4 other companies, the energy coordinator was able to make an estimation of the information costs for a number of energy efficiency improvement investments. Their estimates were in the range of 2-4%.

6.2 decision making

In the interviewed companies, it is the energy department or the technical department which proposes energy conservation investments. Who decides on the investment depends on the size of the investment. Low cost adaptations are approved by the manager of the energy department or the technical department. Medium cost investments are approved by the plant manager, whereas high cost investments are submitted to the corporate board. The definition of low, medium and high costs depended on the size of the turnover of the plant. Decision making cost consist of time spend on meeting and consultation of decision makers.
The approval of a proposed energy efficiency improvement investment depends on a number of factors. First is the payback period (PBP) of the investment. All the interviewed companies used the simple PBP as investment criterion. A typical maximum PBP found for pure energy efficiency improvement measures is 3 years, although a number of energy coordinators indicated that their company uses a lower PBP due to the uncertain economic prospects of their industrial sector. If the investment served other purposes as well (product quality improvement, lower maintenance costs) the maximum PBP could rise to about 5 or 6 years. In one case, the respondent mentioned that a higher PBP was accepted for an innovative project, because it increased experience with a new technology which could probably be used in the company's other production plants. A second factor which appeared to play a role was the personal involvement of company executives and management with energy conservation. One respondent also mentioned the positive influence of covenants (between the government and a branch organisation, in which a branch organisation makes a voluntary agreement to improve its energy efficiency) in interesting the management in energy efficiency improvement.

Only two respondents in the heavy industry sector tried to give an estimation of the decision costs. They estimated decision costs to be between 1 and 2% of the investment.

6.3 implementation

In the interviews, the emphasis was on information costs, decision making costs and monitoring costs, which together form the transaction costs. However, to give an impression of the various costs involved in the implementation phase of an energy efficiency investment, data from the survey is supplemented with literature studies.

Possible costs which can arise in the implementation phase of a project are:
- study costs
- engineering costs
- equipment costs
- installation costs
- adaptation costs
- lost production costs
- operator training costs.

This list is made on the basis of the surveys, with aditional information from TIEB, (various issues) and OTA (1993).
Study costs arise with innovative projects. The application of a new technology for the improvement of energy efficiency brings costs for research and development and upscaling of the technology, or the building of a demonstration model.
Engineering costs arise with designing the integration of technologies into a production process. When new, more energy-efficient equipment is installed, adaptations have to be made in e.g. the piping and ducting system, or motorpower delivery. Generally, the engineering costs are about 10% of the investment (see e.g. Chauvel and Lefebvre, 1989).
Equipment costs are the cost of the new equipment itself.
Installation costs arise with installing the equipment. They mainly consist of labour costs.
Adaptation costs arise when the infrastructure of the plant has to be adapted to allow implementation of the measure, for example if the new measure needs extra space, a reconstruction of the steam network, pressured air piping, etc.
Lost production costs arise if production needs to be halted for the installation of the equipment. Therefore, two energy coordinators said they preferred to install such measures during maintenance stops. However, if installation extends the maintenance down-time, the lost production costs arise.
Operator training costs are made to train personel in the use of new equipment.

Study costs, engineering costs, equipment costs and installation costs are generally included in the cost benefit analysis of firms (as shown by the surveys). Together they form the implementation costs. Adaptation and lost production costs and operator training costs are generally not included in the cost benefit analysis of firms, as shown by the surveys. Hence, they may be also excluded in bottom-up studies. These costs are technology -as well as firm-dependent. Some authors mention these costs to be considerable (eg OTA, 1993), but no estimation of the size of these costs is made.

6.4 monitoring

For the interviewed companies, monitoring the effects of energy conservation investments does not seem to be common practise, except for large investments. Although energy coordinators will probably have an idea of the overall savings of a project, the exact energy efficiency improvement and cost savings of a specific investment are generally not calculated. In the absence of an energy monitoring system, generally no action will be undertaken to calculate the energy savings of an investment.

Three of the companies are installing an energy monitoring system (EMS). The primary goal of an EMS is to attain a better understanding of the energy flows in a plant, and to find ways to use the energy more efficiently. After implementing an EMS, the costs of monitoring the performance of an energy efficiency improvement investment are much lower, and more insight is gained into the energy savings of distinct investments.
The costs for monitoring as a percentage of overall investment costs will be small.

The transaction costs of energy efficiency improvements for large, energy intensive companies are summarized in table 1.

table 1: transaction costs, expressed as part of the investment

information costs	2-6%
decision costs	1-2%
monitoring costs	<1%

7. DISCUSSION

7.1 Comparison with other research

Only a limited amount of research into transaction costs has been found. Masten (1991) calculates the costs of internal organization for a naval ship-building project. These costs were calculated by multiplying the number of hours devoted by management to planning, directing, and supervising a particular component or process by the average hourly management wage. However, organization costs are not equal to transaction costs as defined in this study. The organization costs are the costs for managing and organizing a complete project, whereas the transaction costs are here defined as the costs that come with the purchase and the installation of one energy efficiency improvement measure.
Joskow and Marron (1993) calculate the transaction costs utilities experience in their electricity conservation programs. Björkqvist (1990) calculates the transaction costs of households when purchasing energy efficiency improvement measures. The last example found was an unpublished study on transaction costs in the Netherlands building industry (Vermande, 1994). For this study, a detailed breakdown of the relevant costs was available. Although a different approach was used to calculate the transaction costs, this enabled a comparison of the two calculations.

In february 1992, the Netherlands building companies were accused of trust forming by the European Court of Justice. To prove to the Court that transaction costs were not higher in the Netherlands system of sharing major building orders than in the surrounding countries, the transaction costs were calculated. In the building of a large office (total production costs: Dfl 7 m.) 3 phases were distinguished (Vermande, 1994):

- Project specification. In this phase, costs occur for external payments to architects and structural engineers, and for advice on installations. In this phase, the transaction costs were equal to 10% of the production costs.
- Tendering period. Costs occur for project management, building costs experts, and included bidding costs of the builders. The transaction costs for this phase were equal to 2% of the production costs.
- Construction phase. Transaction costs occur for organization of building activities, monitoring during the construction, and project management. They were equal to 9% of the production costs.

The transaction costs in this research were calculated to be 21% of the production costs of the building. This is significantly more than the transaction costs calculated in this research for the purchase and installation of energy efficiency improvement equipment. The difference can be explained as follows:
- The building research includes the transaction costs made by the suppliers, e.g. bidding costs for various builders. The transaction costs for suppliers of energy efficiency equipment are excluded in the present research.
- Engineering and architectural costs are included in the building study. Engineering costs (estimated at 10% of the investment by e.g. Chauvel and Lefebvre (1989)) are excluded in this study. The reason for this exclusion is that the interviews showed that these costs are generally included in the implementation costs; including them also in transaction costs would lead to double counting.

7.2 Comments on using transaction costs in the field of energy efficiency improvement

Three factors limit the relevance of transaction costs in the context of this research. The first factor is that the information gathered was mainly on retrofit investments. For investments in new constructions, the transaction costs might be different.
The second factor is that in an energy department, much information is gathered on energy efficiency measures which are not implemented. Therefore, if only the information costs for the measures which are implemented are considered, an underestimation is made of the total information costs to companies for energy efficiency improvements. Another approach to calculate the information costs would be to divide the costs of the energy department by the energy efficiency improvements carried out. However, this overlooks the fact that the activities of an energy department not only concern energy efficiency improvement, but also operation and maintenance. A second factor limiting the value

of this research is that transaction costs are only calculated for large, energy intensive firms. For smaller firms, the transaction costs will be different, because they lack an energy department specialising in the gathering and applying of information on energy equipment. A building manager for whom energy is only part of his responsibilities is less familiar with the field of energy efficiency improvement. In many cases he may not be eager to devote his precious time to energy conservation. Because he is less familiar with new energy efficiency improvement techniques, he will experience higher information costs (OTA, 1993). Therefore, transaction costs for energy efficiency improvement for less energy-intensive companies without an energy department may be significantly higher.

7.3 Consequences for the efficiency-gap

The efficiency-gap is defined as the difference between the sum of energy savings that have a positive net present value and the energy efficiency measures which are actually implemented (Levine et al, 1994). The net present value is generally calculated by discounting the benefits of the measure at the real interest rate over the technical lifetime of the measure. Many studies indicate the existence of an energy efficiency gap (Levine et al, 1994, Wilson and Swisher, 1993). Transaction costs are seen as one of the explanations for the efficiency gap.

This research showed that for large companies, the transaction costs are quite low, only 2-8% of the total investment costs. As the large companies represent the largest share of the industrial energy demand (Blok et al, 1992) it is probable that the influence of transaction costs on the efficiency gap is rather small.

A crucial factor in explaining the efficiency gap might be the discount rate. Various studies show that companies generally demand a payback period of 2 to 6 years (Gruber and Brand, 1991; Koot et al, 1984). This was confirmed by the interviews. Only a small fraction of the total energy efficiency improvement potential satisfies such stringent criteria. For example, if a maximum payback period of 3 years is applied to the bottom-up study of de Beer (et al, 1994), the energy efficiency improvement potential in the Netherlands is 13% for the period 1990-2000. For this period, using a real interest rate of 5% to calculate the net present value, the industrial energy efficiency improvement potential with positive net present value is 22%. Adding transaction costs of 10% to all the measures decreases this potential by 0.2% only. However, one of the reasons for the stringent investment criteria used by firms might be the presence of transaction costs.

8. CONCLUSION

This research provides a first impression of the size of transaction costs for investments in energy efficiency improvements in the industry. For twelve large, energy-intensive plants the proces of implementing a number of energy efficiency measures was examined, and the transaction costs associated with the implementation of these measures were estimated.
In the selected companies, the transaction costs mainly consist of information costs, whereas the costs of decision making and monitoring are much smaller. The firms gathered part of the information, on e.g. equipment and supplier options, after the investment decision. This avoids making excessive information costs for investments that are not implemented.
For the companies considered in this study, transaction costs of energy efficiency improvement measures are estimated to be between 3% and 8% of the investment. Hence, transaction cost may only partly explain why large firms do not apply the full potential of energy efficiency improvement. However, this study only deals with large firms, which are able to reduce the information costs by having a technical or energy department specialised in the applying of information on energy issues. For small and medium sized enterprises, the transaction costs might be relatively higher. Furthermore, other costs like adaptation, lost production and operator training costs may play a role.

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